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Declaration under Rule 4.17:

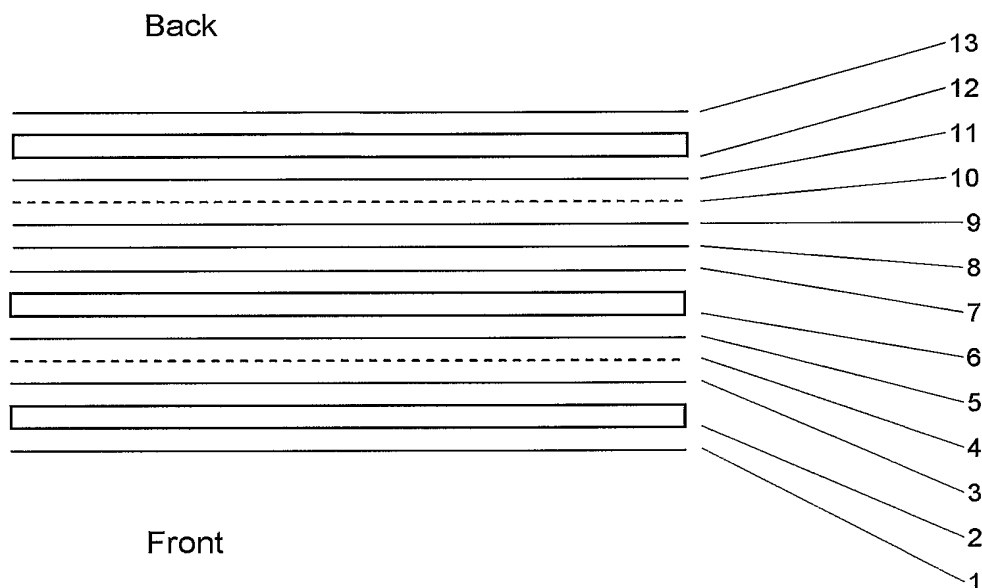
— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: MULTILAYER DISPLAY WITH ACTIVE AND PASSIVE MATRIX DISPLAY LAYERS



(57) Abstract: A multi layer display device including a passive matrix display layer and an active matrix display layer. The combination of passive matrix display layer with an active matrix display layer avoids moiré interference. In addition, as passive matrix displays have much higher transmissivity than active matrix displays, the luminance of the resulting display is much improved. The multi layer display device is useful in mobile electronic devices such as mobile telephones, PDAs, laptop computers and the like.

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IMPROVED DISPLAY

Field of the Invention

The invention relates to multi-layered displays and especially multi layered
5 displays in situations where power consumption is an issue.

Background

Historically mobile phones used monochrome screens. These were segmented
displays similar to those used in digital watches and calculators. The information
10 that could be displayed on these screens was limited to numeric data such as
phone numbers.

The next generation included passive matrix displays. These were still
monochrome. However they had the advantage they could be used to display
pixilated data. These displays had super twisted liquid crystal sandwiched
15 between two pieces of glass. The display had electrodes arranged in columns on
one side and in rows on the other side. A voltage was applied across selected
rows and columns. Where regions with applied voltage intersected, the LC tilted,
causing the screen to go black in the intersecting regions. This system was
relatively flexible. It allowed the display of numbers, letters and even simple
20 images. However, the display was not sophisticated enough to allow the display
of grey scale or colour images.

The next milestone was the development of a passive matrix system where the
voltages applied could be controlled to give differing degrees of tilt at the liquid
crystal. The different tilts allowed different amounts of light through the display.
25 Accordingly this could be used to provide grey scale images. This passive matrix
system could also be used in combination with colour filters to allow the display of
colour images.

These screens though have a tendency to flicker. In addition, they have slow
response times.

30 In response to these issues active matrix screens were developed. These active
matrix screens have a transistor and a capacitor associated with each pixel. This

allows for much quicker response times and much higher resolutions.

However, the inclusion of the transistors, capacitor and colour filters has a cost in terms of transmissivity. That is, the active matrix screens do not allow much light through them. As a result, the backlight needs to produce more light to
5 compensate. This results in the backlight consuming a lot more power than its predecessors.

In recent times development has moved to alternative backlighting technologies such as LEDs and to mechanisms such as light collimation and polarization recycling, to increase the light output of the backlighting units.

10 Multi layer displays are a relatively modern phenomenon. They are described in PCT/NZ98/00098, which is hereby incorporated into this specification. Multi layer displays generally comprise two overlaid layers of active matrix LCD screens.

The advantages of the multi layer display rest with the ability to display two layers of data at the same time. Complex data can be displayed on both the front and
15 rear displays. Usually this data would need to be separated by displaying it on separate displays or in a minimized size so that both can be displayed on the same screen. The multi layer display however splits information across layers. As the information is presented at different distances the human brain is able to distinguish the information into its relative information sets. In this way more
20 information can be presented to and cognised by a user.

The overlay of active matrix LCD screens is not without technical drawbacks. By way of example the overlay leads to the formation of a moiré interference pattern. To overcome this an interstitial material is sandwiched between the active matrix LCD screens. The interstitial material slightly blurs the rear LCD, minimizing the
25 moiré interference. However, it also leads to degradation of the rear LCD image quality. This is discussed in detail in PCT/NZ03/00046.

In addition, the presence of two active matrix LCDs in the optical stack of the multi layer display leads to the loss of a significant proportion of the light exiting the backlight arrangement. This loss is between about 95 and 98%. As a result multi
30 layer displays tend to have a luminance of 150 cdm^{-2} as compared to a regular display with a luminance of $300\text{-}400 \text{ cdm}^{-2}$.

The transmissivity of the typical components of an active matrix display are

recorded in the table below. The transmissivity of specific components from different manufacturers will vary. However, the table provides an indication of the order of transmission you can expect from a typical active matrix display.

Component	Transmissivity
Polariser	0.42
ITO	0.9
Liquid Crystal	.95
Colour Filter	0.33
Aperture Ratio	0.65
<i>Total Transmissivity for a single layer active matrix display:</i>	0.077027

Note: the total transmissivity is the product of the transmissivities of the individual components.

- 5 To try an overcome this, the backlight of a multi layer display is significantly brighter than that in an ordinary display. This of course has a negative effect on the efficiency of the unit making the multi layer display technology unsuitable in situations where power consumption is limited by use of a battery, fuel cell or other storage device. .
- 10 Accordingly there is a need for an improved multi-layer display that overcomes some of the foregoing options or at least provides the public with a useful choice.

Object

- 15 It is an object of the invention to provide an improved multi-layer display, which goes some way to ameliorating the aforementioned problems, or at least provides the public with a useful choice.

Statement of Invention

- 20 In a first aspect the invention relates to a multi layer display device including a passive matrix display layer and an active matrix display layer.

Preferably the active matrix display layer includes colour filters.

Preferably the passive matrix display layer is located in front of the active matrix display layer.

5 More preferably the most forward display layer includes an overlay making it a touch screen.

Preferably the multi layer display device is a mobile phones, PDAs, MP3 players, laptops and tablet computers.

More preferably there is an interstitial glass layer or a space between the passive matrix display layer and the active matrix display layer.

10 In a further related aspect the invention relates to a mobile electronic device incorporating a multi layer display.

Preferably the multi layer display includes a passive matrix display layer and an active matrix display layer.

15 More preferably the passive matrix display layer is located in front of the active matrix display layer.

More preferably there is an interstitial glass layer or a space between the passive matrix display layer and the active matrix display layer.

More preferably the front display layer includes a touch screen overlay.

20 The display medium can be any display matrix that is transmissive. Suitable mediums include liquid crystal, OLED, TOLED and electrophoretic ink.

The polariser may be standard stretched iodine or wire grid polariser.

25 The interstitial glass may be of substantially uniform refractive index. Different effects may be obtained by shaping or patterning or changing the refractive index of the glass. By way of example the interstitial glass may be adapted as a lens providing the illusion of greater depth.

Where a space is provided between the display layers, this is preferably between about 1mm and 15mm.

30 The present invention may be useful for inclusion in mobile devices such as mobile phones, PDAs, MP3 players, laptops and tablet computers. In addition, the invention may be integrated into traditional display media such as desktop

monitors.

The front-most display layer may include a pressure-sensitive (resistive), electrically-sensitive (capacitive), acoustically-sensitive (SAW - surface acoustic wave) or photo-sensitive (infra-red) overlay so that it becomes a touch or pen based display.

The advantage of the above arrangements is the avoidance of overlapping black matrix and colour filters. This is advantageous in a number of aspects. Firstly, the overlapping structures interact to cause Moiré interference. Having two layers of colour filters substantially reduces the brightness of the display. By eliminating one of these structures we can increase the brightness of the display by a factor of between around 2 or 3.

Brief Description of the Drawings

One aspect of the invention will now be described with reference to the attached figure, which displays a schematic representation of one embodiment of the device.

Detailed Description of the Invention

The multi layer display of the present invention avoids the use of multiple layers of black matrix and colour filters by utilizing a mixture of passive and active matrix displays.

The invention centres on the realization that in mobile displays it is unnecessary to allow for the display of complex images on both the front and rear display layers of a multi layer display. In fact, the complex images need only be allowed for on one of the displays. It is preferable to have the complex image data on the rear display and relatively sparse symbolic or textual data on the front display.

This realization represents a significant departure from the current thinking where the drive is towards improving the backlight and other arrangements to ensure sufficient luminance despite the low transmissivity of the active matrix displays.

In this invention then, a marked departure is made, and the passive displays are integrated into the display with the active display.

Referring to attached figure, in a preferred arrangement the multiplayer display of the present invention includes:

1. A linear polariser to analyse the light coming through the front most liquid crystal layer
- 5 2. Glass patterned with passive matrix rows to provide voltage for controlling liquid crystal
3. An alignment layer for liquid crystal to provide the correct pre-tilt.
4. Twisted nematic liquid crystal for optical activity to change light transmission state
- 10 5. Alignment layer to align liquid crystal
6. Glass patterned with passive matrix columns to provide voltage for controlling liquid crystal
7. Wire grid polariser to analyse light coming from rear most layer and provide polarised light for the next layer.
- 15 8. Active matrix ground ITO layer to provide a voltage reference to address against
9. Colour filters to provide the ability to make a particular pixel appear a particular colour
10. Alignment layer for liquid crystal
- 20 11. Liquid crystal to provide optical activity required to change the light transmission state.
12. Active matrix display grid to provide voltage for controlling liquid crystal
13. Rear display glass to provide a substrate for subsequent layers.
14. Rear polariser to polarise light coming from a backlight device.
- 25 Parts 1 to 6 form the passive matrix display layer. Parts 9 to 14 form the active matrix display layer. The distance between the displays provide the depth effect. This can be varied by including a space between the layers or including an interstitial glass or lens layer.

Those skilled in the art will appreciate that this order may be reversed depending

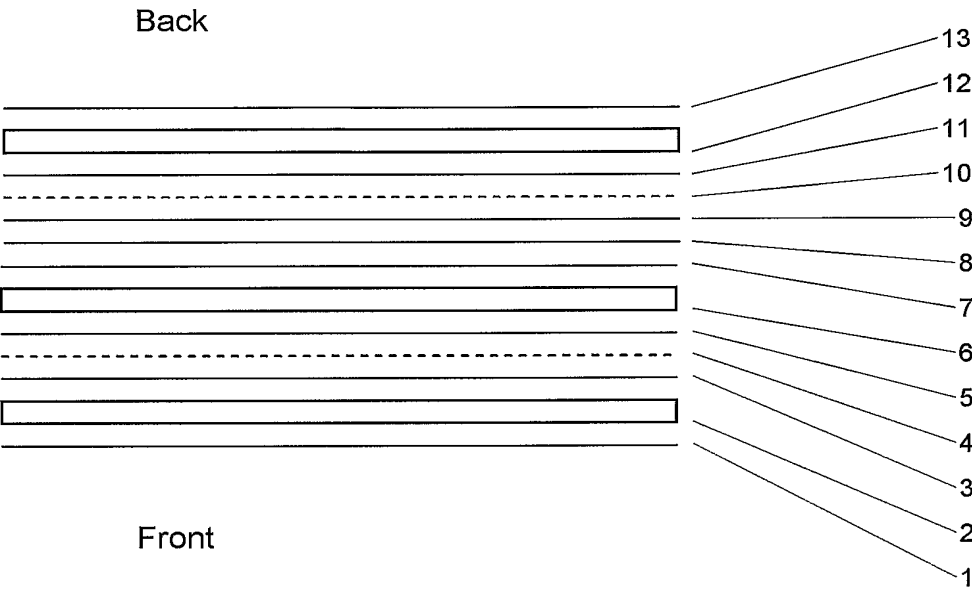
on the application. Additionally, it may be desirable to put the wire grid polariser on the other side of the interstitial glass, or to use two separate displays.

The advantages provided by this stack over prior art include:

- 5 (a) Increased light transmission. This is because the front most liquid crystal component is now without colour filters, capacitors and transistors, the black matrix mask and colour filters. This in turn significantly reduces the burden on a portable power supply, which in turn means the power supply will last longer and be less of a burden in overall size, which is important in portable applications.
- 10 (b) No moiré interference between colour filters on the front display layer and rear display layer. This generally results in the need to blur the image on the rear display layer, which results in a degradation of image quality. Also this blurring needs to be done in a very controlled manner between said polarisers, which results in a relatively expensive component because of the process constraints.
- 15 (c) Decreased display thickness. Mobile applications at present have a display stack that is about 2mm thick. This stack needs to exist inside the device package in conjunction with other components to make the device function. Increases in thickness of as small as 2 or 3 millimeters will make the device too large for users to carry comfortably.
- 20 (d) Reduced mass and manufacturing cost since the two middle pieces of glass has been combined into one.

Claims

1. A multi layer display device including a passive matrix display layer and an active matrix display layer.
2. A multi layer display device as claimed in claim 1 wherein the active matrix display layer includes colour filters.
3. A multi layer display device as claimed in claim 1 wherein the passive matrix display layer is located in front of the active matrix display layer.
4. A multi layer display device as claimed in claim 1 or 3 wherein the most forward display layer includes an overlay making it a touch screen.
5. A multi layer display device as claimed in any of claims 1 to 4 wherein the multi layer display device forms part of a mobile phone, PDA, MP3 player, laptop or tablet computer.
6. A multi layer display device as claimed in any of claims 1 to 5 wherein complex image data can be displayed on the rear display and text or numeric data can be displayed on the front display.
7. A mobile electronic device incorporating a multi layer display.
8. A mobile electronic device as claimed in claim 7 wherein the multi layer display includes a passive matrix display layer and an active matrix display layer.
9. A mobile electronic device as claimed in claim 8 wherein the passive matrix display layer is located in front of the active matrix display layer.
10. A mobile electronic device as claimed in any of claims 7 to 9 wherein the front display layer includes a touch screen overlay.
11. A mobile electronic device as claimed in any of claims 7 to 10 wherein complex image data can be displayed on the rear display and text or numeric data can be displayed on the front display.



INTERNATIONAL SEARCH REPORT

International application No.

PCT/NZ2006/000081

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

G02F 1/1347 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

DWPI, JAPIO Keywords: overlap, stack, overly, overlaid, superpos, superimpos; multilayer, multiscreen, G02F 1/1347; screen, display; passive, monochrome; array, pix, matrix; phone, laptop, calculator, pda, mp3, personal digital

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 09-244057 A (FUJITSU LTD) 19 September 1997 Abstract, paragraphs 2, 13-22, 38, Figure 1 (Figures and translation from http://www.ipdl.ncipi.go.jp/homepg_e.ipdl)	1-11
X	WO 2004/001488 A1 (DEEP VIDEO IMAGING) 31 December 2003 Pages 2, 7-8, Figures	1-11
X	WO 2003/079094 A2 (DEEP VIDEO IMAGING LIMITED) 17 March 2002 Pages 4, 19, 26, 48, Figure 7	1-11



Further documents are listed in the continuation of Box C



See patent family annex

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
04 August 2006

Date of mailing of the international search report

9 AUG 2006

Name and mailing address of the ISA/AU

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/NZ2006/000081

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2003/032058 A1 (DEEP VIDEO IMAGING LIMITED) 11 October 2001 Pages 15-18, Figure 3	7, 10, 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NZ2006/000081

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. A multilayer display device including passive and active matrix display layers (claims 1-6)
2. A mobile electronic device incorporating a multilayer display (claims 7-11).

The only feature common to all of the claims is a multilayer display. However this common feature is generic in the art. This means that the common feature can not constitute a special technical feature within the meaning of PCT Rule 13.2, second sentence, since it makes no contribution over the prior art. Hence the claims lack unity a priori.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/NZ2006/000081

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report			Patent Family Member		
JP	9244057	NONE			
WO	2004001488	AU	2003238973		
WO	03079094	AU	2003217081	US	2006103951
WO	03032058	NZ	514500	US	2005062410
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.					
END OF ANNEX					